The Processing of Airspace Concept Evaluations Using FASTE-CNS as a Pre- or Post-Simulation CNS Analysis Tool.

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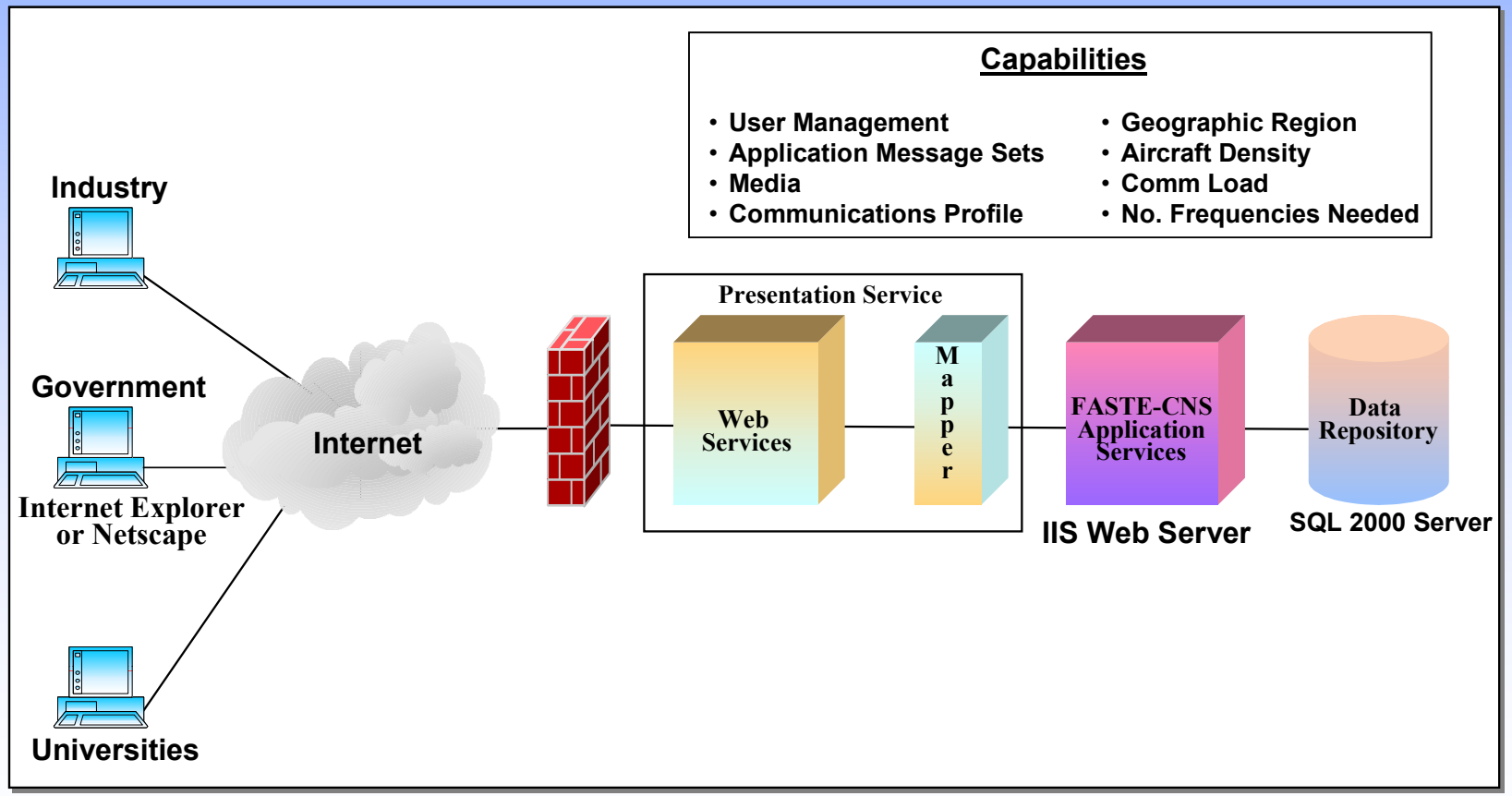
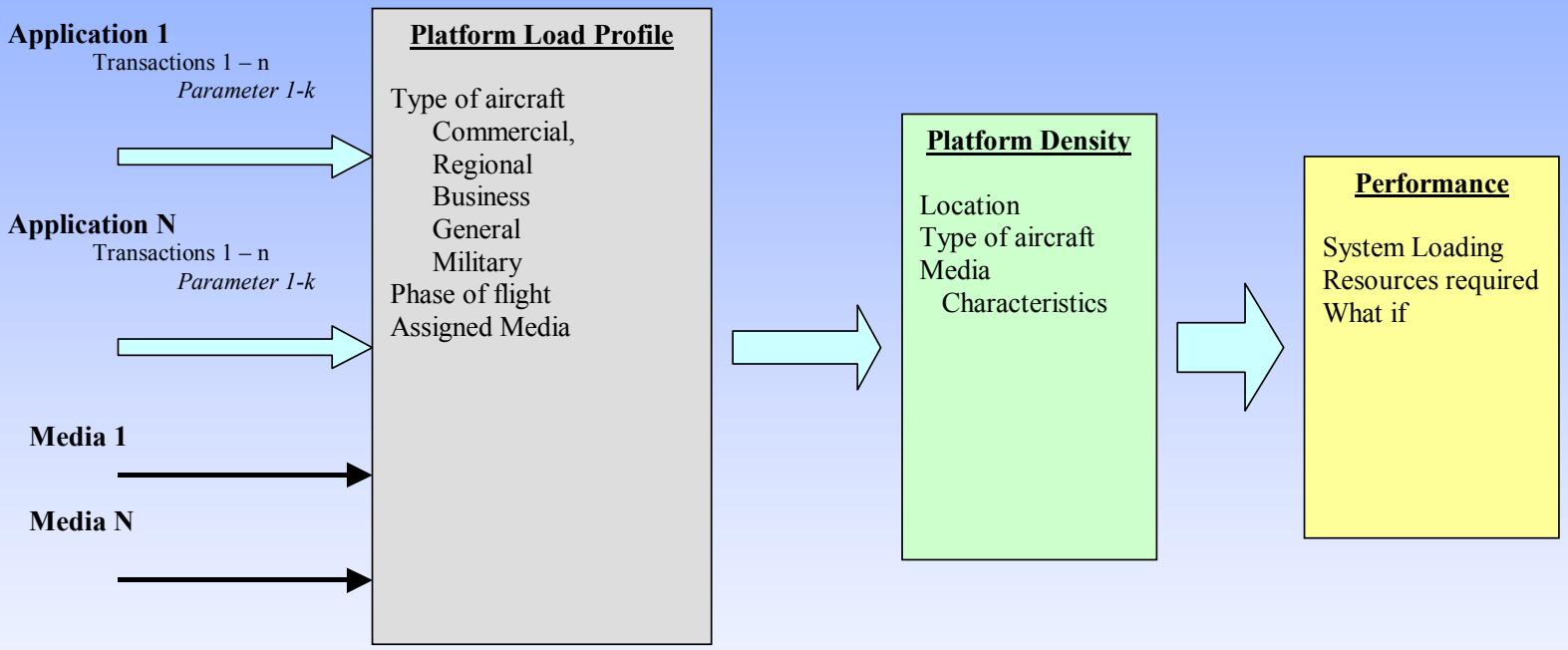
Future Aeronautical Subnetwork Traffic Emulator – Communications, Navigation and Surveillance (FASTE-CNS)



FASTE-CNS Features

- Internet-based
  - Accessible using common web browsers through Internet
- User Accounts
  - User has flexibility to dynamically define geographically regions, number of aircraft, and media; as well as, file management.
- Application Message Sets
  - Define application specific communicated messages
- Communication Traffic Profiles
  - Define series of applications and their associated media
- Communications Forecast Data Model
  - Define geographic region to describe the communications traffic within the selected region
- Frequency and Transmitter Requirements
  - Calculates the frequencies and transmitters needed to support regions defined in density profile

FASTE-CNS Generic Loading Analysis



Airspace Concept Evaluation System (ACES)

- Used to evaluate operational concepts for improving the NAS
- Agent-based simulation of the NAS
- Focuses on representing the physical entities of the NAS (flights, air traffic services, environment).
- No integrated air-ground communication modeled
- Messaging is handled perfectly and instantaneously

Data Sets Generated by ACES

- Aircraft
- Air Traffic Control System Command Center including Monitor Alert
- En Route Traffic Flow Management (TFM) and Air Traffic Control (ATC) including Conflict Detection & Resolution (CD & R) or Advanced Airspace Concepts (AAC)
- Terminal TFM & ATC
- Airport TFM & ATC including Surface Traffic Limitations (STL)
- Airline Operations Center (AOC)
- Traffic Demand
- Winds
- Airspace

Data of Interest from ACES

- Data sent between the Aircraft and En Route TFM/ATC agents is of interest.

FASTE-CNS Performance Models

- Better alignment of the Pre-Analysis Communication capability with ACES.
- Establish Pre-Analysis Navigation and Surveillance
- Post-processing of ACES simulation runs to analysis of C-N-S characteristics.

ACES Pre-Analysis - Communication Model

- Model Inputs:
  - Communication Flight Data set
  - Radio Coverage Area set
  - Communication Media (VDL2, ACARS, Voice)
  - Time period for analysis
  - Amount of acceptable delay
- Model Output:
  - Graphical by RCA, number of frequencies needed for acceptable delay.
  - Tabular by RCA:
    - Average and 95th percentile delay values
    - Number of communication errors

ACES Post-Analysis - Communication Model

- Model Inputs:
  - ACES Output Data set
  - Radio Coverage Area set
  - Communication Media (VDL2, ACARS, Voice)
  - Time period for analysis
  - Amount of acceptable delay
- Model Output:
  - Graphical by RCA, number of frequencies needed for acceptable delay.
  - Tabular by RCA:
    - Average and 95th percentile delay values
    - Number of communication errors

ACES Pre-Analysis – Navigation Model

- User designates: flight plan and Navigation system
- Graphically displays two tracks
  - true position of the aircraft;
  - reported position of aircraft after the effects of navigation system are considered (pilot view)
- Flight plan of aircraft is determined from take-off to landing in one minute segments
- One flight plan considered at a time.
- Navigation systems modeled are Global Positioning System and VHF Omnidirectional Range/Distance Measuring Equipment.

ACES Post-Analysis - Navigation Model

- AircraftStateMessage generated by ACES Simulation form basis for performing post analysis navigation modeling
- Minute-by-minute aircraft location information
- ACES generates 4D reported locations of all of the aircraft
- Navigation System systems available to the user are GPS and VOR/DME.
- Aircraft separation violation reported based on the horizontal and vertical user-defined separation criteria

Navigation Model Details

- GPS
  - AircraftStateMessage reports the aircraft's true position components (latitude, longitude and altitude).
  - Aircraft's true position used as the mean in a normally distributed random number generator with standard deviation for latitude and longitude of 3.15 meters and altitude of 4.75 meters.
- VOR/DME
  - The VOR accuracy of course alignment is considered generally to be within ±1 degree of the true heading.
  - This error shall be normally distributed around the aircraft heading with a standard deviation of ±0.5 degrees.

ACES Pre-Analysis - Surveillance Model

- User designates: flight plan and Surveillance System
- Graphically displays two tracks
  - true position of the aircraft;
  - position of aircraft as presented to ATC controller
- Flight plan of aircraft is determined from take-off to landing in one minute segments
- Surveillance systems modeled are Secondary Surveillance Radar - SSR and Automatic Dependent Surveillance-Broadcast – ADS-B.
- Aircraft separation – user-defined

ACES Post-Analysis - Surveillance Model

- AircraftStateMessage generated by ACES Simulation form basis for performing post analysis surveillance modeling
- Minute-by-minute aircraft location information
- ACES generates 4D reported locations of all of the aircraft
- Surveillance systems modeled are Secondary Surveillance Radar - SSR and Automatic Dependent Surveillance-Broadcast – ADS-B.
- Aircraft separation

Surveillance Model Details

- **Secondary Surveillance Radar – SSR**
  - Accounting for SSR precision, smoothing of tracks and display delays.
  - Inaccuracy in radar precision is dependent on the CD-2 message field resolution which equates to ±1/8nm for en-route radar.
  - Track smoothing keeps transitions between radar sweeps from "jumping" on the controllers console; it will occur about 10% of time.
  - True position (latitude and longitude from AircraftState Message) is mean in a normally distributed random number generator with standard deviation determined by RMS technique, combining errors from radar precision, smoothing and display delay.

Surveillance Model Details

- **Automatic Dependent Surveillance-Broadcast – ADS-B**
  - Accounting for ADS-B precision, smoothing of tracks and display delays.
  - Navigation system precision categorized into 12 values; passed as an accuracy code (NAC_p) – based on navigation system.
  - Track smoothing will occur about 10% of the time – using uniformly distributed random number generator.
  - Display Delay error associated with elapsed time between receiving ADS-B message and aircraft position displayed for controller – normal distribution with standard deviation of 1.7 sec.
  - True position from AircraftStateMessage is the mean in a normally distributed random number generator with standard deviation determined by RMS technique, combining errors from Nav. System precision, smoothing and display delay.

ACES Post-Analysis - Reporting

- Graphical display showing subregion distribution of separation violations.

- Tabular results by subregion of the evaluation of separation criteria – based upon a comparison of the location of each aircraft with those around it; determine if the separation criteria was violated

Conclusion

- Integrated CNS models into ACES is next step
- FASTE-CNS provides opportunity to meet August 2004 VAMS milestone and develop our knowledge of ACES